Analysis of Inter-moss Loops in the Solar Region with IRIS and SDO/AIA: Automatic Event Detection and Characterization

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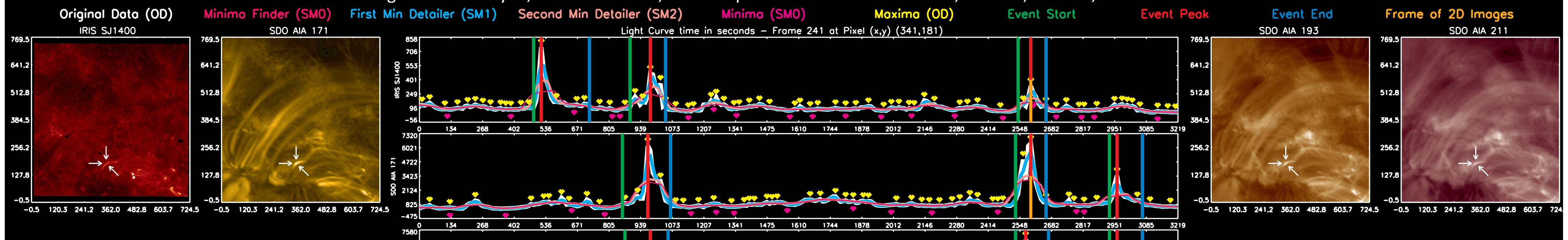
CSPAR

Light Curve Analysis, Event Detection, and Comparison Between IRIS SJ1400, AIA 171, AIA 193, and AIA 211



Background

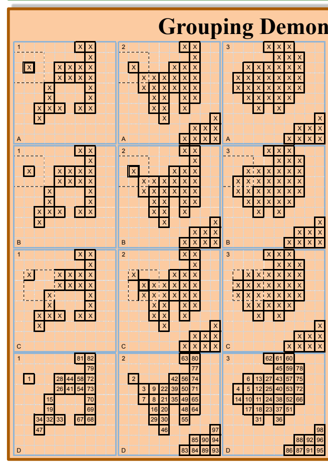
The *Interface Region Imaging Spectrograph (IRIS)*, launched in the summer of 2013, is designed specifically to observe and investigate the transition region and adjacent layers of the solar atmosphere, obtaining images in high spatial, temporal, and spectral resolution.

Our particular work is focused on the evolution of inter-moss loops, which have been detected in the lower corona by the *Atmospheric Imaging Assembly (AIA)* and the *High-Resolution Coronal Imager (Hi-C)*, but are known to have foot points below the transition region. With the high-resolution capabilities of *IRIS* and its Si IV pass band, which measures activity in the upper chromosphere, we can study these magnetic loops in detail and compare their characteristic length and time scales to those obtained from several *AIA* image sets, particularly the 171, 193, and 211 pass bands. By comparing the results between these four data sets, one can potentially establish a measure of the ionization equilibrium for the location in question.

To explore this idea, we found a large, sit-and-stare observation within the *IRIS* database that fit our specifications. This data set contained a number of well-defined inter-moss loops (by visual inspection) with a cadence less than or equal to that of *AIA* (~12 seconds). This particular data set was recorded on October 23, 2013 at 07:09:30, lasting for 3219 seconds with a field of view of 120.6 by 128.1 arcseconds, centered on -53.9 by 59.1 arcseconds from disk center. For ease of comparison, the *AIA* data has been interpolated to match the *IRIS* cadence and resolution.

In the main portion of the poster, we demonstrate the detection of events, the information collected, and the immediate results to the right, showing the progress of an event with green as the start, blue as the peak, and red as the end. Below here, we demonstrate how pixels are combined to form groups. The 3D results are shown to the right.

Grouping Demonstration

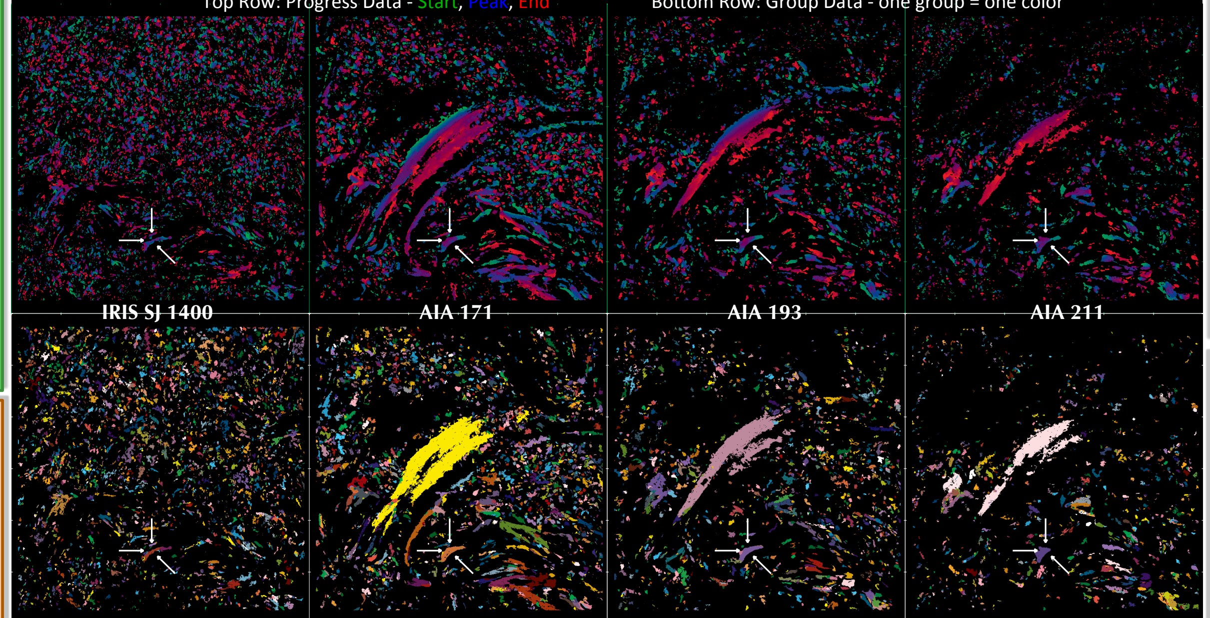


This panel shows the first three steps A, B, & C and the final result D of the grouping process for two example events over three time frames (1,2,3). One can follow along with the numbers in the last row, which show the order that the pixels are collected in.

The first pixel is chosen by a simple scan of the first time frame. While focused on that pixel, the surrounding cube of pixels are also scanned for the event information. If a pixel fits the criteria, it is added to the collection for another scan, just like the first pixel. This can be seen in rows B and C, where the second and third pixels are the focus to look for more event pixels. Once a pixel has been found, it is set to zero so that it is not found more than once. This process is repeated until the entire data cube is scanned.

Top Row: Progress Data - Start, Peak, End

Bottom Row: Group Data - one group = one color



It can be seen in the 1D event detection results above that there are a few notable events that peak at nearly identical times within the four data sets. We use an orange marker in the linear plots to show the point in time that is associated with the white arrows in all 2D plots above. In the row just below the 1D results, the arrows are pointing to a blue pixel, which signifies the peak of the event. This row shows the progress data. At this and any snapshot in time, all spatial pixels are labeled with a value associated with the relative progress through the current event at that location. This data comes directly from the processing of the event detection algorithm to the entire data set. These progress values along with lifetimes of events are then used as a limiting criteria when the pixels are grouped. A simple example of the grouping algorithm is shown to the left with explanation. While a pixel is in the spot light, the surrounding pixels must have lifetime and progress values within 20% of that pixel in order to be included in the group. During this part of the algorithm, statistical data is collected about each group, e.g., the dimensions of the box containing a single group (length, width, duration) and the number of pixels within that box associated with the same event. Each group is also labeled with a number for reference and a color index. Given the vast number of groups collected, a complex color table was developed to display the variety of groups in the bottom row above, where each group is represented by a single color.

Conclusions

For the *IRIS* data set, the algorithms outlined here have found more than a 50 million events, resulting in more than 400,000 groups. For the purpose of only finding inter-moss loops, these results would be considered a bit extreme. However, by setting a very low standard for the qualifications of an event, we have collected a valuable set of statistics that can potentially be used to define the events that we want. Two examples of these statistics are shown just below.

In the first figure below, the majority of the groups are small and short-lived, while the largest *few* are likely to be grouped too generously due to complex activity within the region. Minus these top few, the larger groups are most likely associated with the inter-moss loops that we had set out to find. In the lower figure, we can see some type of division between two general types of groups for durations below or above ~12 pixels or ~124 seconds in time.

The progress of this work is currently involved in the automatic characterization of groups and how comparisons between these four data sets can lead to an interpretation of the local state of ionization. The automatic characterization will need to include a variety of special cases given the complex nature of all structures seen within the results. One particular issue is the likelihood of the appearance of events in the *IRIS* data before or after an event is seen in all three *AIA* data sets. This is one of the criteria that would be able to characterize the level of ionization. If interested, see lead author for more examples from this data set.

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Statistical Results